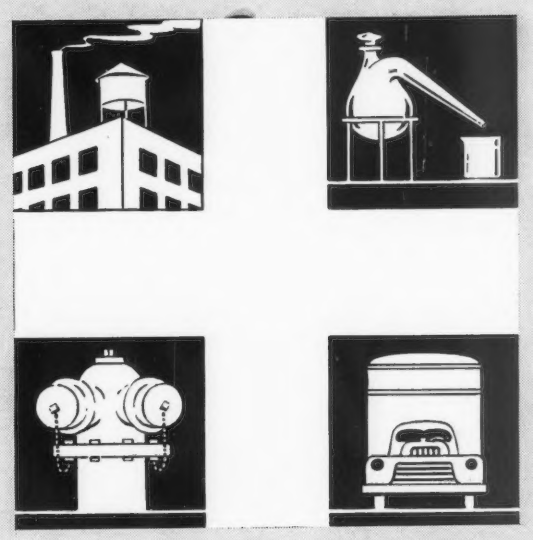
The Journal

OF THE AMERICAN SOCIETY OF SAFETY ENGINEERS



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WITH THIS fourth issue our Society's new Journal completes its first year of publication. The many compliments we have received during this initial year have been gratifying indeed. Also deeply appreciated have been the many fine articles we have received from members and others, some unsolicited and some in gracious response to our requests. It is our hope and determination to continue publication of the Journal with material of the same excellent quality we have been privileged to present in our first four issues. To accomplish this, however, will take more than our hope and determination. It also will require the cooperation of all chapters and members of the Society in keeping alert for article possibilities . . . in encouraging others to write and to submit their manuscripts to us . . . in authoring Journal articles based on their own valuable research and experience . . . in taking a personal interest in and assuming a personal responsibility for the maintenance of the Journal's high standards, volunteering their ideas and their services at every possible opportunity.—

—The Editor

Our President Speaks on SAFETY

I SAW a tree give up its life to save mine. It had been growing in the median strip of a modern divided highway.

The tree was uprooted by a passenger car that, out of control, swerved off the pavement and headed toward the oncoming lanes and a solid stream of Sunday afternoon traffic, including the car in which I was a passenger. The only thing between us and disaster was this lone shade tree, into which the car crashed, then veered and rolled over onto its top.

The tree, torn out by its roots, showered clods of earth over us. The car, inverted, its wheels still spinning in the air and its horn blowing continuously in a forlorn wail, was a wreck.

Lying inside on the car top was a girl. She was conscious and looked at me helplessly as I thrust back tree branches to get to her. She was in complete shock. When I assured her she was safe she closed her eyes and laid very still. In the group of onlookers which had collected, so quickly, was a registered nurse who took over the girl's care till an ambulance could arrive.

Brushing the dirt from my clothes, I got back into the car. The young family I was driving with had almost recovered from the shock of our near encounter. In a few minutes it was all over as far as we were concerned. Or was it really over for us?

Our car was plastered with earth from the life-saving tree roots. The one year old girl, sitting in the back seat with her mother, still had traces of dirt on her dress, though in blissful ignorance of her close call with death.

And the three year old boy, who had been sitting with his father and me in the front seat, was still bewildered. Many miles from the scene he kept repeating, "Why were the wheels still running, Daddy? Why did the car hit the tree?"

We couldn't explain to his satisfaction—or to our own. We knew only that we had just witnessed another Sunday afternoon highway tragedy and that, but for the tree that had given up its life to save us, we and perhaps others following closely behind us would have been added to the long list of highway casualties.

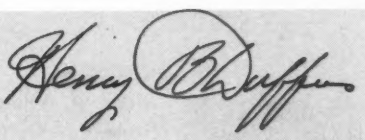
The tree, the clods of earth, the upturned car, the girl lying helpless inside—all these pictures already were fading into the past. But the little boy, even after I had told him a story in an effort to get his mind off the incident, kept repeating his question.

"Daddy, why did the car hit the tree?"

The answer to this far from childish question lies deep in the fields of human and engineering research. Its importance places a heavy responsibility upon us who have dedicated ourselves to the reduction of this needless waste of human lives in industry, on the highway, in the home.

As members of the American Society of Safety Engineers we must align ourselves with, and give moral and, if possible, financial support to the many research projects now underway to find causes and cures for the human and mechanical errors which result in such costly tragedy.

If we are to be true to the ideals of our Society, we must combine our efforts as safety engineers to bring about more effective control of needless highway accidents.



Henry B. Duffus, President
American Society of Safety Engineers

SOHIO Serious Injury INDEX

by A. R. Klingel and O. C. Haier

SEVERAL years ago it seemed to the management of the Manufacturing Department of the Standard Oil Company (Ohio) that the steady improvement in the disabling frequency rate had come to an end. A review of the statistics revealed that in 1953, for the first time in a number of years, there was an increase in the number of injuries. This was contrary to the experience of the refining industry. Figure 1 shows a comparison of disabling injury frequency rates of Sohio's five refineries with those of the refining industry as reported by the American Petroleum Institute.

What happened in 1953? What would happen in 1954? Would the rate go up again or would it resume its downward trend? These and similar questions suggested that the Operations Research group might help.

The statisticians, applying control chart techniques to the annual frequency rates for the period of 1949 to 1953, concluded that the small number of injuries involved did not lend themselves satisfactorily to short term predictability.

Frequency Rate Inadequate for Purpose

This was even more obvious when the records of individual plants were studied. Figure 2 shows a typical charting of the number of disabling injuries for six month periods in one refinery. It is obvious from the chart that the level of safety performance is at the point where long periods without any disabling injuries are probable at this plant. To use this chart to measure the effectiveness of the safety program in the succeeding six or twelve month period is not possible.

For example, assume that a perfect new approach to injury prevention is discovered and applied at this plant. During the next six month period, zero disabling injuries would be reported and plotted on Figure 2. A cursory examination of the past data or the application of probability theory indicates that even without this new approach, this result (zero injuries) could have been expected more often than not.

Need New Short Term Measurement

Thus, there would be little rational justification for claiming any accomplishment at all due to our hypothesized theoretically perfect program. As a matter of fact, at Sohio's present level of injury frequency, it would require a number of years before the improvement could be detected with reasonable certainty.

It became apparent to the statisticians that some measure other than disabling injuries would have to be used to measure safety program effectiveness, at least on a short term basis.

For a number of years many safety engineers have felt that the disabling injury frequency rate is inadequate to tell the entire story of safety program effectiveness. They know that many non-disabling cases have almost the same circumstances and factors as disabling cases. The main differences often are minute elements of time, space or location. Yet, these cases may never find their way into the traditional measure of safety program effectiveness—the disabling injury frequency rate.

With these thoughts in mind, Sohio's safety engineers developed what is now known as the Sohio Serious Injury Index. Disabling injuries, plus certain kinds of non-disabling ones which are considered serious or potentially serious, are included in the Index. Thus the Index includes the following types:

1. Non-disabling eye injuries from work-produced objects or corrosive liquids, requiring treatment

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Otto C. Haier, manager of safety, has been with Sohio since 1947, previously had 11 years' safety experience with Carnegie Illinois Steel, holds a B.S. in M.E. from the University of Illinois. He is serving as general chairman of the Northern Ohio Chapter, American Society of Safety Engineers for the chapter's 1956-57 activity year.

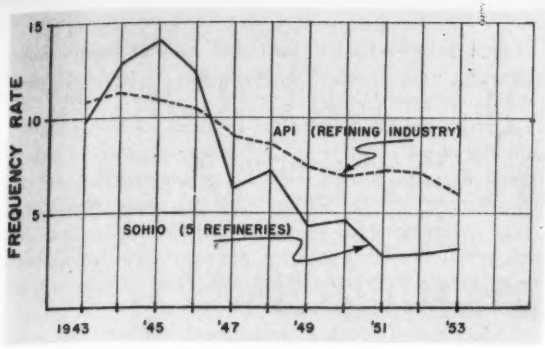


Figure 1
Disabling Injury Frequency Rates

by a physician. (Wind-blown objects are not included.)

2. Non-disabling fractures.
3. Non-disabling lacerations requiring suture.
4. Non-disabling injuries for which the attending physician prescribes work restrictions or motion limitations.
5. All disabling injuries.

It will be apparent to all safety engineers that this group includes most of the injuries generally considered serious. They were selected also because they fitted into a pattern of easily recognizable types, about which there could be no differences of opinion as to reportability.

For example, in the case of eye injuries our medical director's standing orders to plant nurses (each refinery has a nurse) states in part that if a foreign object in the eye cannot be removed with two or three passes of a sterile swab, the injured employe must be referred to an eye specialist. Thus if the nurses carry out their standing orders, all such cases will be reported.

Classification Problems Minor

There will be no particular questions about non-disabling fractures since these are usually determined by X-rays as ordered by the attending physician.

Since only our attending physicians suture lacerations, the only problem involved is that of a nurse deciding which cases should be referred to the physician. This is a very minor problem since there are frequent visits to the dispensary by the doctors.

Admittedly, there may be some discrepancies in determining that motion limitations or work restrictions are necessary. Doctors' attitudes and knowledge of the injured man's work vary, and influence their decisions. However, we have found that these injuries include many sprains, strains and back injuries, which are rather universally recognized as requiring such measures.

Disabling injuries are, of course, judged according to the nationally accepted American Standards Association's Standard Z16.1-1954, *American Standard Method of Recording and Measuring Work Injury Experience.*

The number of these injuries, expressed on a "per million employe-hour" basis, gives us our Index number.

Sohio's Research Operations group, working with the Safety group, came in with fresh ideas and techniques to help us interpret and evaluate our statistics in a scientific manner. The statisticians suggested that we apply "control chart" techniques and the concepts of random or chance variations to make the Index or frequency rate of serious injuries a more meaningful measure. The vast majority of control chart applications to date have been directed towards control and interpretations of machine performance. However, within the last few years numerous applications in the personnel fields have been made. [1,2,3,4,5]

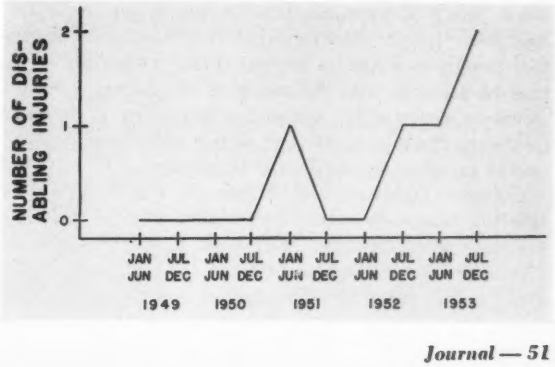
The control chart is based on the concept that any measure of performance will be subject to random or chance variation for which there will be no readily or easily discernible cause. When some specific influence, either very effective or very ineffective, is brought to bear on the problem, the variation will no longer be due to chance. The influence will show up as very low or very high levels of performance.

Chart Serious Injuries by Plant

In our case, the number of serious injuries per million employe-hours is plotted monthly on a control chart for each individual refinery. A mean or average monthly figure calculated from the previous three year period is shown as a solid horizontal line on the chart. Control limits also are calculated. These are shown on the chart as horizontal dotted or dashed lines above and below the mean. These control limits are the estimated amount of random variation which can be expected to occur without any *change in the kind or intensity of injury prevention activities.* They are based on the assumption that accident occurrences for a given level of accidents will be distributed according to a Poisson distribution pattern.[6] Although use of other distribution types, [7,8] might give improved estimates of control limits, analysis and experience with our own data indicate the Poisson to be adequate for our control chart purposes.

A typical control chart for one of the five refineries is shown in Figure 3. This shows the Index (frequency of serious injuries per million employe-hours worked) plotted monthly for 1954 and 1955, with the mean and the control limits in place. Note that for the first 11 months of 1954, the variations were not too far above or below the mean, and always within the upper and lower control limits. This indicates that the injury prevention techniques and activities in this plant were no more nor

Figure 2
Disabling Injuries in One Refinery



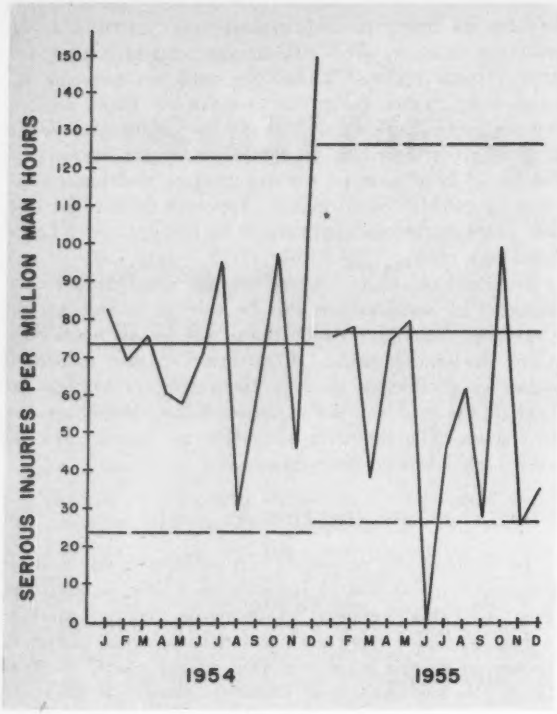


Figure 3
Serious Injury Index for One Refinery

no less effective than they had been for some time past.

In December, however, the Index jumped to an extremely high level, considerably above the upper control limit. This was an indication that something had gone wrong. With the control limits placed at ± two standard deviations from the mean, the odds were almost 40 to 1 that something significant had taken place to cause December's Index to be so high. It was now squarely up to the safety engineer to begin to dig, to discover the cause of that significant change and institute measures to eliminate or counterbalance the bad influence.

Index Points Out Immediate Trend

The monthly plotting for 1955 on Figure 3 shows how successful the countereffortts were. Only three Index points—February, May and October—were above the mean, while June was zero, far below the lower limit. November was slightly below the lower limit. Here again, when June's performance was known, it was the safety engineer's job to discover what had been done during that month to influence serious injury frequency. This type of plotting, with the numbers of injuries involved, can show if something unusual is happening at the plant to change the injury rate and at the same time show the overall trend in serious injury frequency.

Contrast Figure 3 with Figure 4, which shows the monthly frequency rates of disabling injuries only for the same plant. One can readily see how inadequate the disabling injury frequency rate is for accurately measuring safety program effectiveness, except long range.

Conclusion

Sohio believes that in its Sohio Serious Injury Index it can tell rapidly when good or bad injury prevention techniques are being used.

A much greater number of injuries are being studied and therefore a better job of injury prevention can be done. Everyone knows the value of playing the spotlight on a larger area of activity. By the same token, when large numbers of all kinds of injuries, rather than just one or two disabling injuries, are exposed to public view, techniques are sharpened or new ones are sought and applied to show improvement.

Sohio Manufacturing Department management representatives at all levels have wholeheartedly accepted the use of the Sohio Serious Injury Index and are enthusiastic about its value. With the disabling injury frequency rate for the Manufacturing Department dropping from 3.25 in 1953 (see Figure 1) to 1.26 in 1954 and 1.55 in 1955 and, with the number of serious injuries on the decrease also, there is confidence that the prevention of injuries is being accomplished.

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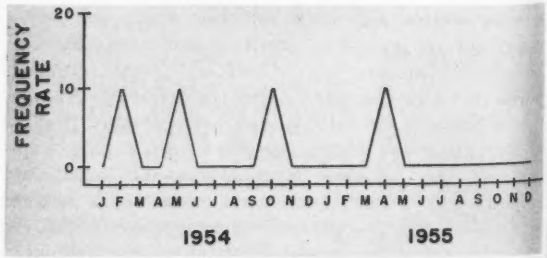
Figure 4
Disabling Injury Frequency Rate for One Refinery



PRINCIPLES OF ACCIDENT PREVENTION AND CONTROLS

by George F. Nuernberger

Industrial safety programs, to be effective, need the interest and active leadership of top management in all phases of planning and administration.

IT CAN BE assumed, and it is hoped "safely," that readers of this magazine for safety engineers have all accepted the fundamental fact that accidents are not inevitable or unavoidable. They are the result of human errors or defective material and equipment. They are wrong in principle because they cause pain, suffering and economic loss.

In our form of society where great emphasis is placed on leadership, we must necessarily expect the leaders of industry to be the planners for accident prevention. Planning for accident prevention requires evaluation of needs, establishment of objectives, assignment of responsibilities and authority to acquire the materials needed, just as planning for production of a marketable product requires coordination of men, money, materials and machines.

The leaders of industry must select men qualified in the field of accident prevention to assist them in the understanding of their responsibility. Their responsibility, however, does not end at the planning stage. It must be constant, giving emphasis to the responsibility placed on the supervisor and the employe.

As an example of effective planning, I would like to cite a policy originated by a management team that was clarifying all the company's personnel policies in a written form. This company safety policy stated objectives that are both specific and broad enough to give direction at all levels within the organization.

Policy

It is the policy of the company to provide safe working conditions and practices by utilizing the best available safety engineering, equipment and methods, and by requiring employe cooperation and participation in the safety program.

Safety Engineer

To assist the supervisory organization in maintaining the company policy, a safety engineer is retained in a staff capacity. The safety engineer is responsible for:

1. Appraising the effectiveness of existing safety programs, procedures and facilities, and making recommendations to responsible supervisors.
2. Providing technical assistance and advice on safety matters to the entire organization.
3. Counseling with supervisors on safety problems.

Supervisor Plays Key Role

In this accident prevention program the supervisor carries the key role. The broad policy gives him direction as to how his aims will be supported by upper management and also outlines his specific responsibilities.

George F. Nuernberger is safety engineer for the A. B. Dick Company, Chicago. Graduated from Marquette University in civil engineering in 1937, he has spent most of his professional life in accident prevention work. Since 1954 he has served as national treasurer and Finance Committee chairman for the American Society of Safety Engineers.

During development tool design is reviewed for production and operator safety factors.

Accident Prevention Principles *Continued*

Supervisors

The company depends on supervision for the successful administration of the safety program. Supervisors are responsible for:

1. Maintaining safe working conditions and practices in operations under their supervision.
2. Observing and training subordinates in safe work practices.
3. Bringing to the attention of other supervisors concerned any unsafe work conditions or practices which involve employes not reporting to them.
4. Seeking the advice of the safety engineer in the solution of specific safety problems, and evaluating the effectiveness of the safety program in their departments.
5. Investigating, reporting and analyzing conditions which led to recent accidents and taking steps to prevent the recurrence of similar accidents.
6. Obtaining medical attention for any ill or injured personnel.
7. Determining the need for, obtaining and administering the proper use of personal employe protective equipment.
8. Maintaining clean and orderly conditions in areas under their jurisdiction and avoiding the accumulation of unnecessary materials.
9. Overseeing the safety of their subordinates in the event of fire, at which time they will supervise the evacuation of their employes from any immediate danger area. When a plant-wide evacuation is signaled, the supervisors are responsible for evacuating their personnel according to plan.

Need Employe Participation

The policy also recognizes the importance of employe participation in the success of the program. To formalize this participation, it outlines the specific employe responsibilities.

Employes

No safety program can be successful without the conscientious cooperation of all employes. It is therefore required that employes:

1. Observe all safety regulations in the performance of their jobs.
2. Notify their supervisor immediately whenever they feel their job is unsafe.
3. Avoid the wearing of personal clothing and jewelry which may be unsafe in the performance of their job.

The drafting board is where safety begins, as part of designer's concept of the tool.

4. Use protective equipment and clothing prescribed for their job. Employes are responsible for personal protective equipment issued to them.

Further, the policy meets management's requirements for continuing interest in the program. This is accomplished by reporting full details of each and every failure in the successful administration of the policy. This is in addition to the responsibility placed on the safety engineer to issue periodic reports to all levels of management and employes.

Every industrial accident prevention program utilizes three areas or methods of control, formally or informally. These are tried and proven but, for the program to be successful over a long period of time, they must be used in the proper proportions to fit the conditions. As conditions and situations change, controls must be adjusted and emphasis shifted to produce the desired results.

It should be emphasized that the three areas of control to be considered here are not the only ones but it is in these areas we have the most knowledge. Daily research is progressing throughout the country and important information in other areas is being fitted together. The result will be that the job of accident prevention will become still more effective.

The three methods of accident control we know the most about are (1) engineering control, (2) work procedures or work methods control and (3) personnel control.

Engineering Control

Engineering control must set standards of facilities that provide for adequate layout, standards of equipment design that minimize hazardous situations, standards of process that control potentially hazardous conditions when the human element is introduced and standards of materials that outline the basic measures if the material is of a hazardous nature. Standards of preventive maintenance, a phase of engineering control, are essential to assure the reliability of the devices restraining the hazardous condition.

Engineering control is established by analysis of hazardous conditions. We must apply four steps:

1—Control by removal of the hazard.

2—Control by minimizing the hazard.

3—Control by guarding against the hazard.

4—Control by utilizing safety devices.

Great strides in the area of engineering control have been effected over the years in modern layout, automatic machines, production lines, etc. We can expect even greater advances in the future. It is inevitable because we are constantly demanding greater and greater efficiency of the industrial process. Industrial accidents reduce that efficiency. Therefore, the professional safety engineer and all the other members of the industrial management team are working toward the same goal—reducing accidents to nil.

Work Procedures Control

Accident control can also be established by work procedures or methods control. In this area, the analysis of work procedures on all jobs—the more hazardous as well as the less hazardous—must be considered so that ultimately all jobs are reviewed from the standpoint of how they can result in an accident and what methods or safe procedures must be used to make sure the accident-producing situation does not develop. Methods control also includes the use of injury preventers such as personal protective equipment.

After these steps have been taken, control still is not established until workers are trained in safe procedures. It must be recognized that in addition to the initial training, follow-up and retraining are parts of the program.

Personnel Control

The third area of accident control is personnel control. This requires the establishment of personnel and medical standards. Past job history is an important source of information on the man's stability. These standards involve physical testing of people through medical examination and checks of skills, dexterity, vision, muscular coordination and other physical factors that have an influence on the hazards of the job that is to be performed.

We might also include psychological testing to determine whether or not the individual has the proper mental attitude for the group with which he is to work. If the job is the pressure type, we might test his ability to cope with its demands. Certainly it should be made clear that psychological factors are important only in those areas where there is a proven relationship.

By no means least is the important factor of mental ability. Here again, however, the findings of evaluation depend a great deal on the type of mental ability needed.

Along with the establishment of physical and medical

As tool is being built toolmakers, designers discuss production and safety features.

Completed tool in operation (right) shows safety features built in to remove hazard when operator puts hands into "danger zone" of punch press die. Design of tool incorporates interlock gates which, when opened, disconnect control circuit of press, automatically swing die blocks into position, prevent any possible injury to operator.

standards, information must be obtained on the relationship of job requirements to these personal characteristics. An important aspect of personnel control is the matching of physical characteristics, skills, mental ability and psychological demands of the job to the worker.

One very important way that personnel control can further accident prevention work is through group motivation. Safety demands the use of publicity, contests, posters, attitude surveys and communications of all forms. This is well covered in the literature and should be integrated in the program.

The last aspect of personnel control is counseling. This is a new field in many industries but is rapidly taking on greater importance. Many accident prevention men look on counseling with a certain skepticism. They are like the farmer who was approached by a salesman with a set of books on how to farm. The farmer's comment was, "What do I want with those books? I've been on this farm for 25 years, and I'm not farming as good as I know how yet."

This field of personnel counseling bears watching because it is here that tendencies toward accident proneness can be and are uncovered. Then patterns can be developed to bring them under control.

These three simplified methods of accident control, (1) engineering, (2) work procedures and (3) personnel control, are all present in varying degrees in every successful accident prevention program. The characteristics of the business, the structure of management and the type of employes all influence which phase requires the most emphasis. Certainly the individual directing the program will have special techniques. When a program lacks that certain spark, it may be in one of these areas that we can find the clue to revitalize it.

Application of Controls

So much for the controls themselves. How can they be applied? Establishment of this program of control will vary in nearly every company. It will, however, generally follow this pattern:

First, the hazards must be evaluated by gathering and analyzing the facts about exposure. Facts are obtained from accident records and from inspections made by the safety engineer or perhaps, in the case of some special problem, by an outside agency.

Facts on occupational health hazards can be gathered through the use of instruments operated by qualified persons within or outside the company. After the facts have been obtained, we must analyze the type of exposure, its frequency and severity. With this information the problem is fairly well outlined and the personal experiences of the safety engineer and others in the field will provide direction to the type of corrective action that should be promoted.

After evaluation of the hazards, the program of control is ready for activation. In the area of engineering control it must be recognized that already there are methods set up to meet standards for quantity and quality of production. Why not make sure those methods include accident prevention engineering control when they are being developed?

One way could be to have the same group that develops quality and quantity standards also develop safety standards to be engineered into a process. A safety specialist's advice will be needed the first time this is done. However, if the safety specialist has evaluated the hazards in terms the engineer can use and understand, the engineer will soon learn to recognize the close relationship between his engineering methods and injuries to the working force. Then he will develop the most accident free processes.

In addition to engineering, there is another important group closely associated with the work procedures or methods area of accident control. These are the industrial engineers, time study or work standards people. Though primarily concerned with doing the job in the simplest manner and establishing a rate for it, the work standards man must understand hazards and how they result in accidents.

It is an accepted part of his job that he specify in detail the elements for doing the work. He must have thorough knowledge of accident-producing situations so that he allows sufficient time for safe operation and does not introduce short cuts that have the potential of causing unwarranted hazards. The time study or work standards man must be informed constantly by the supervisor of any element change in the job so that the time allowance can be adjusted.

An important contribution to safety is the ability of an industrial engineer to recognize phases of an operation in which time increases, though they make immediate costs higher, will ultimately save both time and money by increasing safety. He will also be on the alert for awkward setups, tooling, material arrangements, etc.

It is fundamental to train supervisors so that they, in turn, know how to train properly the individual in his job operation. The technique of supervisory training is well covered in the literature and a sound program that fits the needs must be used.

The right way to do the job is the safe way. Assuming that we are doing the best job possible in developing standards and that those standards are being implemented by the best engineering methods, it then is essential to make sure the supervisor or trainer knows the job elements. He must also know how to recognize and evaluate hazards so that he can train workers to avoid them. He will recognize certain hazards that even well trained workers cannot avoid. He has the responsibility to call such conditions to the attention of those who can correct them.

Conclusion

There are many experts in each of these areas of accident control in an industrial organization. It is necessary to have management understand that accidents are a by-product of production; that they are not inevitable or unavoidable. Accident prevention is management's responsibility first, supervision's second, and the employe's third, and is an integral part of the production process.

Effective accident control is a matter of management concern. It is so closely tied in with all aspects of production and has such a bearing on good employe and public relations that it is one of the major factors in profitably and successfully operating a company.

"MACHINE GUARDING"

by Walter E. Montgomery

Ancient principles of safety, known by the Babylonians in 2000 B.C., are valid today: Provide the best possible guard and give the worker constant safety education and training.

Walter E. Montgomery is safety director, Kenneth B. S. Robertson Ltd., Montreal, where he has been a safety consultant for 23 years. He has held many chapter and national offices in the American Society of Safety Engineers, has served as a director of the National Safety Council, is consultant to the Canadian military.

TODAY'S accident experience, if compared with that of 50 years ago, would show relatively few disabling injuries attributed to inadequate machine guarding.

Yet even a superficial examination of current reports will show that many accidents—far too many—still occur at machines; that these accidents contribute substantially to the frequency and severity rates which industry is working constantly to reduce.

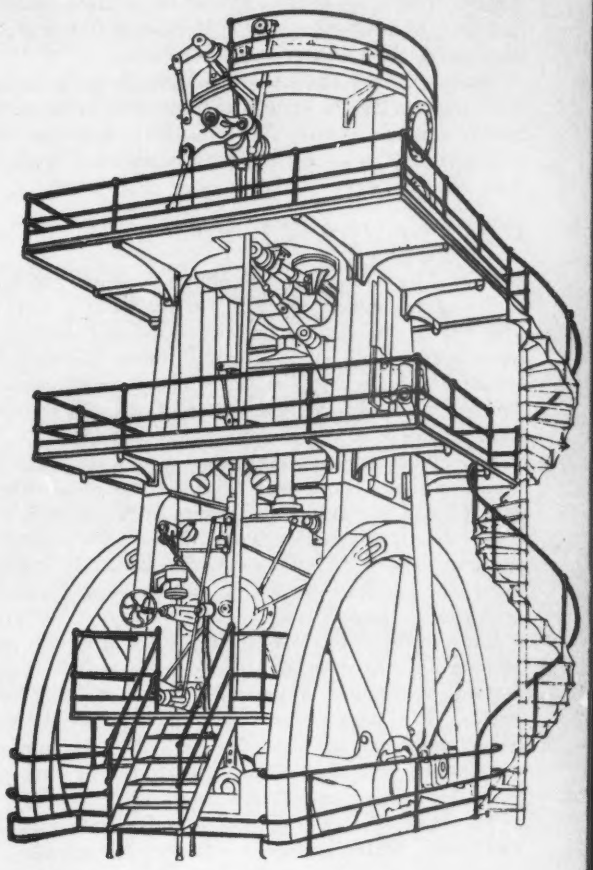
Of these accidents which occur at machines, some few happen under conditions where no physical guards have been provided. In other cases, no guard has been developed which will completely eliminate the hazard involved in operation of the machine. And many times accidents occur because the guard provided was not being used or the safety procedures established were not being followed by the operator.

Even though industry has progressed far in the field of accident prevention, there still is a large area which can be improved only through diligent application of the basic principles of machine guarding. Therefore, even though these principles are merely ideas about safety that have their roots in ancient times, it would seem that conditions call for their constant repetition and reexamination to inspire their use with renewed vigor and dedication.

These principles, expressed in the simplest terms, are to provide the best possible guards and to give the worker constant safety education and training.

And if there is nothing new about these principles, there also is nothing new about the ways people get hurt. After all, injuries are not inflicted by inanimate machines; injuries are caused by a force which is uncontrolled or

NOTE ON ILLUSTRATIONS: Except where otherwise indicated, the illustrations for this article are taken from The Prevention of Accidents *by John Calder, published in 1899, Longmans Green and Company, London.*



Vertical steam engine above has fencing as required by Factory Act of 1878, London, which states that "service platforms and approaches must be fenced in every case, both at outer edges and sides nearest machinery; double rails, the upper one of which should not be less than three feet in height and a fender or coaming six inches deep at foot level should be used."

improperly applied. Actually, the safety engineer is dealing with universal problems which have plagued mankind throughout history.

Accident prevention efforts did not begin in this century. Many of the hazards we think of as unique to our modern mechanical age were faced by the builders of King Solomon's temple, the Egyptian pyramids and the great wall of China. Necessity became the mother of invention, and thousands of years ago safety fundamentals were developed.

As early as 2000 B.C., the building code of King Hammurabi of Babylon contained construction safety rules, with severe penalties for noncompliance.

Two thousand years ago safety had progressed to the use of protective masks, which Pliny described in his *Natural History* as being made of transparent bladders and worn by workers to protect themselves from metallic dust during the preparation of vermilion.

George Bauer, better known as Agricola, in his famous 1556 treatise, *De Re Metallica*, discussed building safeguards in mines to protect mine workers. In listing mine accidents that had occurred, he commented, "Often, indeed, the negligence of the foreman is to blame."

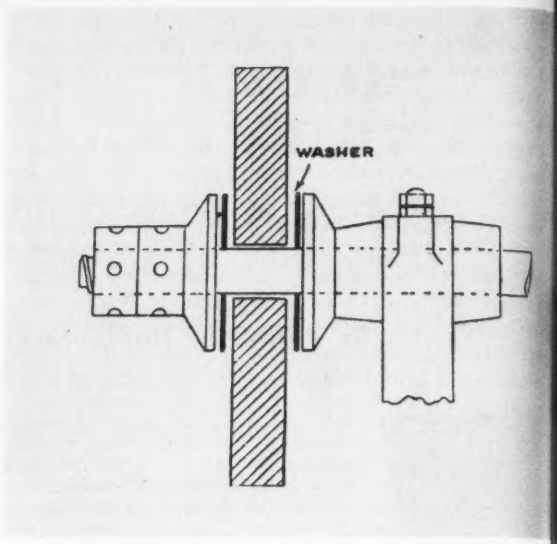


Figure shows safe grindstone mounting using a disc of India rubber or dry cardboard on each side between flanges as was required by the British Factory Act of 1895.

Deals with Age-Old Problems

Such human problems continue to present a challenge to the safety engineer today, of course. When he is faced with human failings such as carelessness and inattention, he is dealing with an industrial problem observed and recorded as early as the middle of the sixteenth century. The modern safety engineer likewise deals with mechanical problems that, in principle, are far from new.

For instance, steam pumps were being used to dewater mines in 1690. James Watt improved the steam engine in 1765 and it was used to power ships by 1800, and trains shortly thereafter. While these early engines of the reciprocating type have only limited use in industry today, the problems created by high pressure steam and high speed machinery remain.

But in spite of the fact that machines have been with us for many years, very few safety engineers will suggest that our development of physical guards has reached perfection. This area needs much further concentration. Those who have made studies of the matter estimate that ten per cent of all work accidents can be attributed to inadequate mechanical guarding.

The installation of mechanical safeguards also can add greatly to the employe's efficiency by removing his anxiety about the hazards of his job. Fear, and the distractions it sets up, not only slows production but renders employes even more prone to accidental injury.

It is, of course, useless to provide guards if they are not kept in position. While foremen should be held strictly responsible for misplaced protection, the basic fault often lies in the design or construction of the guard itself. Sometimes the designer fails to take into account some essential detail of operating procedure with which the guard seriously interferes and which may even increase the danger. In either case, the guard comes off and stays off as long as the operator is able to manage it.

In considering the overall effectiveness of any guard, perhaps the following four points can be used as a basis for judgment:

1. Protection afforded should be complete and continuous, and should protect absolutely the careless and the thoughtless. Not only should a guard protect the regular attendant but also the oiler, the mechanic and others in the vicinity. It should not be necessary to disturb a guard during the course of lubrication, ordinary adjustment, cleaning or other routine procedures. Bearings should be external to the guards unless remote oiling is used.

2. Protection should be designed to avoid interference with work that should be performed while the machine is in operation, and moving machinery should be visible through the guard.

3. Protection should be strong enough to withstand ordinary impact with a reasonable factor of safety with due allowance for wear and tear and frequent removal. We should never fail to appreciate, when designing belt guards, that a 100 horsepower motor has a 100 horsepower belt.

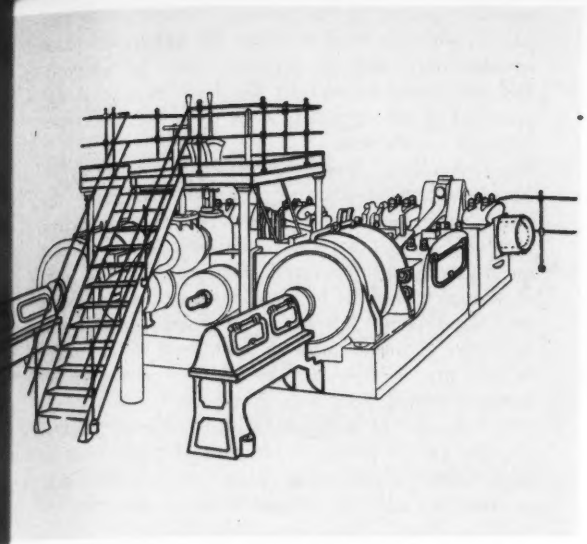
4. Protection should be as simple as possible, without complicated mechanical features.

In brief, a good guard provides maximum protection, does not interfere with production, provides adequate containment or isolation and is of simple construction.

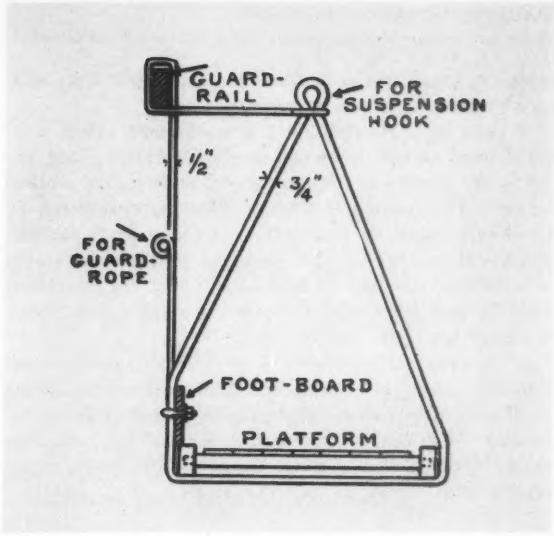
It is not always possible to satisfy all these requirements to the fullest extent. However, after learning fully the process and function of the machine, we should strive to design and apply the most effective guard that conditions will permit.

Education Often Neglected

While poor design may be a very important reason for an employe's failing to use a guard, another primary



Statutory protection (1870) on rolling mill engine includes platform, hand rails and coaming. Also shown, as required by statute, is a shield at the side of the slide block path and a complete cover casting over the projecting ends of the piston rods.



Above is a sketch of a recommended rig for a suspension scaffold. This drawing was first published in an early American scaffolding handbook which came out in 1910.

Sketch below, from the 1910 American scaffolding handbook, showed safe way to construct a horse platform. Text stressed that four nails were required at point A while two were adequate at B. A six foot board also was considered essential by the author.

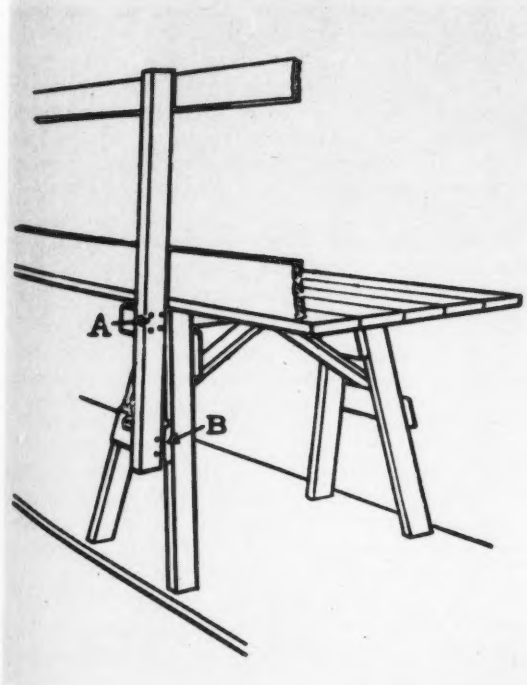
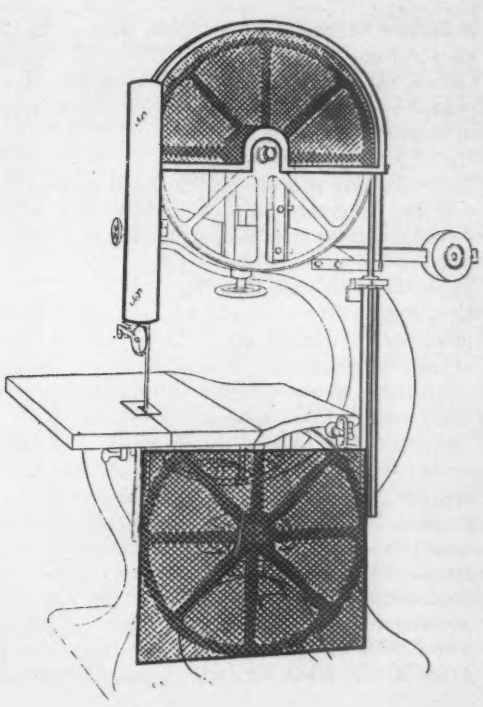


Figure below shows a well protected band saw (1875) in which wire netting, wood or other material was used to fence the moving parts below the bench and at the top of the pulley. Tubing or wood guides protected vertical portions of saw not used in cutting. On saws which had top pulley set lower, it was considered necessary to screen entire top pulley by extending the shield downward.



reason is found in the fact that too often the safety education of the operator is neglected.

A growing realization that a workman's safety does not depend altogether on the excellence of the guard has led to the placing of increasing emphasis on the worker himself. The operator's attitude must be considered as a potential cause of accidents or, from a more positive standpoint, as one of the strongest possible deterrents to accidents. He must be sold on the need for protection and educated in the procedures and precautions necessary to assure his safety on the job.

A comprehensive philosophy on which to build a well rounded guarding program has been outlined by Henry H. Hepburn, former chief deputy inspector of factories, London. Writing in *The British Journal of Industrial Safety* (Spring and Summer issue, 1948), he listed 11 fundamental principles, as follows:

Lists 11 Fundamentals

1. *The Principle of Inevitability.*
   An injury-producing accident will inevitably occur to a person employed on a machine having parts which experience has proved to be dangerous and which is normally used with the said parts not securely guarded.
2. *The Principle of Intrinsic Danger.*
   Certain parts or combinations of parts are intrinsically dangerous in that they have caused accidents in the past, are causing them at the present time and will continue to cause them in the future. In the assessment of the degree of danger likely to be encountered with any group of dangerous parts it is advisable, for absolute safety, to disregard associated functions such as rate of revolution, velocity of sliding parts and frequency of approach to parts. Experience has shown that, given intrinsic danger, an accident will inevitably occur, by the Law of Chance as enunciated by Heinrich, should the required combination be repeated a sufficient number of times.
3. *The Principle of Non-Reliance.*
   In the assessment of the degree of danger associated with any dangerous parts of machinery, no reliance should be placed upon the cooperation of any person employed in avoiding the accident.
4. *The Principle of Elimination.*
   Dangerous parts of machinery inevitably produce accidents so that, if all accidents are to be prevented, the danger of the said parts must be eliminated either by construction or by secure guarding.
5. *The Principle of No-Risk and Non-Use.*
   The intrinsic danger of certain parts of machinery having been established, it is essential for the prevention of accidents that no person should be exposed to the risk of injury at a machine possessing such parts when the dangers have not been eliminated. If the machine is dangerous in any respect it must not be used until rendered safe either by reconstruction or by secure guarding.
6. *The Principle of Training in Safety Precautions.*
   Since accidents will inevitably happen should unsafe acts be repeated by the personal factor, it is essential, in addition to eliminating the dangerous parts of machinery, that all persons should be properly and constantly trained in the knowledge and application of safe practice so as to reduce the repetition of unsafe acts.
7. *The Principle of Production Safety Efficiency.*
   The overall production efficiency of machinery depends upon the separate efficiencies of each factor involved. It is, therefore, essential for obtaining the highest possible overall efficiency, that not only should each machine be maintained at the maximum working efficiency but that all dangerous parts should be securely guarded and all operatives fully trained in safe practices so that the material and personal factor efficiency may be a maximum.
8. *The Principle of Safeguarding for Reverse Motion.*
   The design and fitting of any type of guard must be such that the dangerous parts are securely safeguarded not only for motion in the normal running way but also for their reverse motion.
9. *The Principle of Priority of Use of a Fixed Guard.*
   A fixed guard must always be the first preference for the safeguarding of dangerous parts of machinery and, if some redesign or rearrangement of the machine parts would enable such a guard to be used, then the necessary arrangements should be provided or redesign effected. However, we should not lose sight of the basic premise or the fact that even if any automatic guard is a good one its use is not justified if a fixed guard can be used instead.
10. *The Principle of the Best Guard Known.*
    The standard of any guard for any particular dangerous parts of machinery in a factory must be that of the best and most efficient guard known in the country as a whole and not merely that of the best guard in the district where the factory is located.
11. *The Principle of the Two-Hand Control.*
    Where the hands of the operator are necessarily placed between dangerous parts of a machine when the latter are at rest then, in addition to the requisite fitting of a suitable guard, the starting controls must be so designed as to require the operator to remove both hands from the danger area and use them to manipulate separate control devices, which must be independent in action but complementary in effect.

Hepburn concludes: "If we observe the 11 basic principles to govern a machine guarding program, there need be no major differences of opinion as to whether a machine should be guarded or not."

Need Uniformity in Decisions

This final comment becomes doubly important when it is considered that many safety engineers have been seriously handicapped because their recommendations have been considered as personal opinions, which have carried weight only in proportion to the importance which management has placed in its safety personnel.

When management is convinced that guarding is not subject to frustrating variations and that safety engineers can speak as of one mind, then the members of the profession will have earned a truly high position in industry.

The Mean Amines

Increasing use of these compounds is producing new problems for the safety engineer and the industrial hygienist.

by Philip J. Bailey

DURING the past several years the use of the amines as components of epoxy and isocyanate resin formulations has become more widespread in industry. The amines are used as hardening or curing agents for the resins when used as adhesives or bonding devices with such things as fibre-glass and plastics. They are being used more frequently with these resins in casting, laminating, molding and other structural applications. One such use, recently perfected, has been the fabrication of a fibre-glass reservoir which safely holds a pressure of 3000 pounds per square inch of compressed gas. This is a reservoir as strong as steel, yet with only a fraction of steel's weight.

But these amine curing and hardening agents are presently providing king-size headaches for the safety engineer and the industrial physician. All of the amines are strongly alkaline, causing caustic burns when coming in direct contact with the skin. Some of the newer curing or hardening agents, while not quite so caustic, provide another problem because of their dye base, which upon oxidation makes dark spots on clothing which in turn stains anything it comes in contact with, and quite permanently.

This dye base also causes the skin to turn yellow, a coloration that can only be removed by a long passage of time, plus removal of the individual from further contact with the amine while he is bleaching out.

However, the most insidious damage perpetrated by the amines is caused by frequent exposures to low concentrations of these catalysts. Such exposures, after a period of weeks, months or even years, will produce a sensitization-type dermatitis which may become more extensive and severe with progressive exposures.

This sensitivity usually makes its first appearance around the eyes of the victim, which become swollen almost shut. This happens most suddenly—so suddenly, in fact, that a person who has been working with the curing agent for some time without any apparent trouble may attribute the sudden swelling and intolerable itching to something else. Hive-like swelling on the face and neck usually accompanies the attack. This pattern of physical discomfort continues as long as the individual is exposed to the vapors of the amines.

Thereafter, although the swelling and itching subside, the sensitivity to the amines in many cases is quite permanent, and it becomes necessary to remove the person from any further exposure. Because of this required transfer of skilled workers, loss caused by the sensitivity factor alone can be considerable.

Doctor Thomas W. Nale, medical director of the Industrial Medical and Toxicology Department, Union Carbide and Carbon Corporation, wrote, in part, in September, 1954, in answer to the author's query about Dr. Nale's experience with the amines:

"It is our understanding that the majority of individuals who become sensitized to such materials (amines) develop a sensitivity which is quite permanent and it is necessary to remove them from exposure. Once a person becomes sensitized a very minimal exposure can cause a return of the symptoms."

Doctor Nale goes on to say in his letter, "These hardeners can be handled in such a manner as to prevent any excessive exposure." The author's experience confirms this statement.

The chief medical officer of a large aircraft company who had these amine sensitivity problems to contend with made the following statements:

"New employes, engaged in glass cloth lamination using a resin with an amine solvent-catalyst, reacted with

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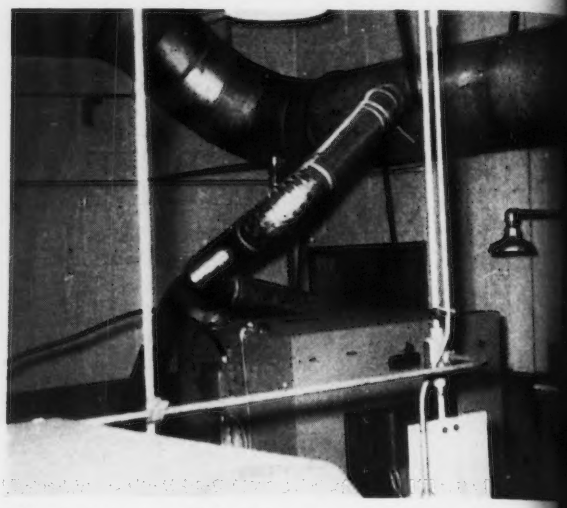
Employe who works with amines and resins prepares to apply barrier cream to face and hands. He has washed thoroughly with soap and water before applying the barrier cream.



Above is a partial view of ventilation system in resin-amine operation. Each machine, oven and chamber is exhausted through 3500 cfm line overhead. Note emergency shower.

THE MEAN AMINES *Continued*

a skin irritation within 12 to 21 days after exposure. The hands, arms and face were affected, especially in the folds of the skin where perspiration appears to be most dense. Men with fair complexions, blue eyes and thin skin appear to react more violently than those with thick, sallow skin."

For some unknown reason some individuals may never become sensitized to the amines. Others may take years to become sensitized. The theory that persons with darker skins have higher immunity to the sensitizing effects than blond or fair-skinned persons has not been proven conclusively. One company that has tried out this theory has still had a high incidence of amine-dermatitis among its darker-than-blond personnel. The color or texture of the skin seems to provide no real or sustained immunity to overexposure.

Many cases are on record where individuals who have become acutely afflicted and then recovered, after removal from exposure, have had violent return of the swellings and itchings after walking through a room where a small open vial of the amine was present.

There also are cases where the symptoms have returned because the individual was working in an air-conditioned room in which air, returned from a section where the amine was being used, was recirculated in his work area.

Should the amine be splashed into the eyes it will cause severe damage very rapidly. High vapor concentrations also will produce eye irritation and attack the mucous membranes.

No history is available at the present time that would indicate any acute systemic poisoning from contact with the amines. Of course, they should not be taken internally for the same reason that insecticides, dyestuffs or resins should not be placed in the mouth or swallowed.

The free amines are here to stay because they are serving more and more frequently in industry and are becoming an integral part of many fabricating and structural processes. They are reaching out even further, into the do-it-yourself workshops in the home, into pleasure-boat building and repair, plastic repair and model making, and they are being found more and more frequently in airplane hangars and garages.

Used occasionally or infrequently, they present no problem and may never cause trouble. However, when they are used certain primary safeguards must be set up and maintained.

The most important st p in the prevention of amine-dermatitis is proper personal hygiene. Skin contact with the amines must be minimized. This includes the solvents and the formulated mixtures of resin and amine.

Personnel working with these materials and mixtures should be provided with showers, washbowls, mild soaps, clean towels, aprons, coveralls, gloves, barrier creams and refatting creams. There also should be a designated time for cleanup before mealtimes, smoking and other break periods.

When the skin is contaminated it should be cleaned thoroughly with soap and water. If there is massive spillage upon the person, remove the wet clothing at once and shower the body with water. Thereafter treat the area of contamination as you would any chemical burn.

Emergency eye and body showers should be provided to treat quickly all accidental eye and body contacts. Eyes should be washed for fifteen minutes with copious

XU

Worker wears gloves, apron, plastic sleeves in cleaning machine parts that contact formulated materials. Exhausted chamber has sliding door, two arm holes, glass window.

Ventilating system and gloves are necessary for safety of chemist measuring amine and resin for repair job. Sheet of cellophane across booth's face protects from splashes.

amounts of water in cases of accidental contamination. Then, if there is any question of serious eye involvement, such a case should be referred to an ophthalmologist.

Wearing of soiled or contaminated clothing should be discouraged. Coveralls or aprons should be used by all persons who have continual or prolonged contact with the materials.

Gloves should be worn to avoid any possibility of skin contact. When the gloves become contaminated, as they will, they should be reconditioned by washing in acetone or alcohol, followed by soap and water.

Protective creams of the barrier type have proven effective if used regularly and properly on face, neck, hands and arms. However, care must be taken that the amines are not locked to the skin under the cream. Skin must be washed thoroughly with soap and water before applying the cream. Usually the barrier creams that provide protection against alkalis will provide some measure of protection against the amines.

Full face shields to protect the eyes are advisable whenever there is danger of splashing.

All operations of mixing and application should be hooded and ventilated, and the entire working area, including the processing and fabricating machines, should have excellent exhaust ventilation facilities.

Working in elevated temperatures increases the hazard of personal contamination and thereby increases the importance of observing the recommended safe practices and procedures. Curing is usually done in ovens at temperatures from 160 degrees to 300 degrees Fahrenheit. Therefore, these ovens should be hooded to carry off any escaping amine vapor released by the increased temperature.

Worker demonstrates emergency combination body and eye shower. Pulling chain will deluge body with 40 gallons of water a minute. A foot pedal activates the twin eye wash.

Worker places decal label around neck of a fibre-glass sphere. Protective equipment includes apron, plastic sleeves and rubber gloves to keep the resin material off hands.

THE MEAN AMINES *Continued*

Tests have indicated that once the marriage of the resin and the catalyst has taken place no sensitizing danger exists. However, any method of regenerating the vapor—by contact with a solvent, by sawing, milling or grinding the hardened material—can set up a new exposure to the sensitizing action of the amine.

The free amines are flammable liquids, as are the solvents that are frequently used with them to clean machine parts, winding or other devices that come in contact with the compounded materials. Therefore, standard procedures for providing fire protection should be followed. Safety cans should be used for storing the acetone or other solvent used for cleaning parts and all handling of these solvents should be conducted in a well ventilated area. Carbon dioxide portable fire extinguishers are quite effective in fighting and controlling early blazes.

The amine catalysts can be worked with every day, safely, without serious consequences, so long as we respect them. Housekeeping, hygiene, protective clothing, proper handling techniques and ventilation are the important things to remember.

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Steel-strong reservoirs, being packed for shipment, though light, will hold 3000 psi.

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AMERICAN SOCIETY OF SAFETY ENGINEERS

Membership Information

THE American Society of Safety Engineers has established the following classifications of active membership:

MEMBER—To be eligible as a Member an applicant shall be at least thirty years of age and shall be engaged in safety engineering. In addition, he shall have either an engineering or science degree in an accredited college curriculum and the equivalent of eight full years' experience in safety engineering; or he shall have had the equivalent of ten full years' experience in safety engineering.

ASSOCIATE MEMBER—To be eligible as an Associate Member an applicant shall be at least twenty-five years of age and shall be engaged in safety engineering. In addition, he shall have either an engineering or science degree in an accredited college curriculum and the equivalent of three full years' experience in safety engineering; or he shall have the equivalent of five full years' experience in safety engineering; or he shall have either an engineering or science degree in an accredited college curriculum, ten years' experience in professional engineering work and one full year's experience in safety engineering; or he shall have twenty years' experience in engineering work, of which at least ten have been at the professional level, and one full year's experience in safety engineering.

JUNIOR MEMBER—To be eligible as a Junior Member an applicant shall be at least twenty years of age and shall be engaged in safety engineering work, which if pursued the required time will tend to qualify the applicant for the grade of Associate Member. In addition, he shall have either an engineering or science degree in an accredited college curriculum or he shall have had the equivalent of one full year's experience in safety engineering.

AFFILIATE MEMBER—The Society also provides a special classification, that of Affiliate Member, for those not professionally engaged in safety engineering. To be eligible as an Affiliate Member an applicant shall be at least twenty-five years of age and shall have contributed to the advancement of safety engineering through demonstrated achievement in some related field of interest in which he has been engaged for at least three years.

for additional information write to

The American Society of Safety Engineers
425 North Michigan Avenue
Chicago 11, Illinois

(or contact your local chapter)

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